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PHYSICS AND ENGINEERING LABORATORY

D.S.I.R.

NEW ZEALAND

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FIRST QUARTERLY REPORT
LANDSAT II INVESTIGATION PROGRAM
NO. 28230.

REPORT NO. 508 MARCH 1976

Principal Investigator:

Dr Mervyn C. Probine

Co-Investigators:

Dr Richard P. Suggate

Mr Ian F. Stirling

Mr Michael G. McGreevy

ORIGINAL CONTAINS
COLOR ILLUSTRATIONS

FOREWORD

This is the first quarterly report of the New Zealand Landsat II Investigation Programme (No. 28230).

The first Landsat II scene of New Zealand was taken on 3 August 1975 and was received by us at the end of October. Since then there has been a steady flow of imagery and, although there are still gaps in coverage due to poor cloud conditions over some parts of New Zealand during December, January and February, we now have a fair coverage of the eastern half of the South Island and along the centre line of the North Island.

In spite of the relatively short time for which the Co-investigators, and our own team here at the Physics & Engineering Laboratory, have had access to imagery, very pleasing progress has been made. For example, the Lands & Survey Department is now using the imagery as a relief shading tool in their Aeronautical Mapping Branch. This will improve land form recognition and also show up general geoform trends. The Department is also using the imagery to check on coastline invagination - particularly with regard to changes which might have occurred since the time of the original survey.

Although the imagery so far received contains only limited forested areas, good progress is being made in correlating the Landsat imagery with underflight data. This will allow species type and volume information to be obtained with a minimum of aircraft data. The information will also be used for quantifying disease levels.

In the geological programme Landsat images are being used to confirm existing knowledge and, in addition, some broad morphological differences which were previously only locally inferred, appear to have regional significance. Here again, the early information coming to hand is encouraging.

The New Zealand programme is organised around a specialist group at the Physics & Engineering Laboratory which exists to develop and promote Remote Sensing techniques and to assist all of the co-investigators and other users. Its prime function for this programme is to acquire, process and disseminate imagery to the co-investigators, and to develop back-up services

in the form of aerial underflight photography, laboratory facilities, and interpretative methods. The report shows that excellent progress is being made in achieving this aim, and the team, under Dr Peter Ellis, is rapidly building up the skills needed to assist users in this country.

The details of each of the individual investigations (PEL Remote Sensing group, Lands & Survey program, Forestry program, and Geological program) are given as separate parts of this report. They have been presented in one volume so that the New Zealand program can be seen as a whole.

I would like to acknowledge the excellent assistance we have received from NASA, and, in particular, from Dr Robert Price. Information has been readily forthcoming when requested and we have had two very valuable and informative discussions with Dr Price and other specialists at NASA via the "Peacesat" communication satellite. These sessions have been of a great deal of assistance and have enabled us, and a number of potential users, to gain information on the uses and limitations of the satellite.

We have also established an excellent collaboration with colleagues in Australia - particularly with Dr M.J. Duggin of the Mineral Research Laboratories of CSIRO in Sydney. We have had exchange visits between the two laboratories and have been able to share and pool our knowledge, and to develop our programmes in a complementary way through this co-operation.

We believe that the programme is off to a good start and we look forward to a continuing and fruitful collaboration with NASA on this project.

M.C. Probine
Principal Investigator

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PART I

DEVELOPMENT OF REMOTE SENSING TECHNOLOGY IN NEW ZEALAND

Investigation No.: 28230

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Remote Sensing Section Report: - RS 76/01

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LIST OF ILLUSTRATIONS

1. INTRODUCTION

The Remote Sensing Section at P.E.L. was formed after the original submissions to NASA for participation in the Landsat II program.

In this first report, it therefore seems appropriate to outline briefly the functions of this group and its relation to the three Co-investigators and other interested groups in this country.

The section exists to develop and promote remote sensing techniques and to assist all potential users. For this reason, it is based in the Physics and Engineering Laboratory, and not allied to any one particular Earth science discipline.

The present staff consists of three scientists and two technicians (Appendix one). During the period of the Landsat investigations, the prime function is to acquire, process and disseminate imagery to the Co-investigators, and to develop backup services in the form of aerial underflight photography, laboratory facilities and interpretative methods.

Imagery from Landsat II received from the Eros Data Center is immediately distributed to the Co-investigators, and the P.E.L. copies are used to make color composite transparencies, from which numbers of prints are produced. The wider dissemination of this imagery among other potential users is achieved with the help of the Department of Lands and Survey, who make available color composite and monochrome prints through the National Photo Library. "Quick look" prints containing four images on one sheet are now being circulated to standing order customers.

Although the Remote Sensing Section is not specifically concerned with one particular discipline, the development program can only be conducted with real data. In particular, land use, forest and crop classification and thematic mapping techniques are relevant to two of the Co-investigators, and are of vital concern to the economy of this country. Pictures taken by Landsat I showed that individual features, for instance paddocks in the Canterbury Plains area were clearly distinguishable, and an area with a rich

diversity of spectral signatures has been chosen as a test site.

Aircraft and ground truth coverage of this site is organised on a regular basis to coincide with the satellite overpass if weather permits. It is hoped that this programme will be of benefit to the Department of Lands and Survey (Co-investigator) for land use inventory and to the Ministry of Agriculture through crop inventory and assessment, who are co-operating in this venture.

On behalf of the Forest Research Institute (Co-investigator), the section has organised a number of aircraft multispectral surveys over the Kaingaroa State Forest, and is presently assisting in providing interpretative facilities.

The section also has a co-operative program with the remote sensing group at the Minerals Research Laboratories, CSIRO, Sydney, Australia, described in section 2.7.

2. TECHNIQUES

2.1 Photographic Processing

The small color processing laboratory includes a color additive viewer (I^2S), a 10" x 10" color enlarger (Chromega) and a film and print processor (Mafi). Landsat II 70 mm transparencies, (MSS bands 4, 5 and 7) are used to produce color composite negatives from which prints and enlargements are subsequently made.

Some difficulty has been experienced in obtaining sufficiently precise registration with conventional color additive methods, and the composite transparencies are now made by punch registering the 1:1,000,000 scale monochrome images and sequentially exposing these in contact with the color negative. Figure 1 is an example of the full-scene color composite produced by this method.

For optimum visual discrimination of most land based targets, we find that the preferred color balance of the false color composite shifts the NASA grey scale towards the green. Specifically the fourth step from the highest radiance end has the following CIE tristimulus values: $Y = 0.6$, $x = 0.29$, $y = 0.32$.

All aircraft multispectral imagery is also processed in this laboratory.

2.2 Aircraft Program

Figure 2 shows the four camera multispectral system developed at P.E.L. The hinged camera can be withdrawn from the viewing port until required for operation, and the system has built in anti-vibration mounts and drift correction. Each camera is fitted with a multilayer interference filter defining the MSS spectral bands. At present we are using Tri-X (Kodak 2403 aerographic) for MSS bands 4 and 5, and Kodak 2424 aerographic film for bands 6 and 7.

The problem with photographic film is to establish the relation between image density and target radiance in each spectral band. Rather than trying to reduce the variables associated with film processing, we have elected to measure target radiance at the time of flight. Mounted in the viewing plane of each single-lens reflex camera is a silicon photodiode, and associated amplifier. The apertured detector views the target through the camera multilayer filter and has an instantaneous field of view (angular) of 0.35°.

The test site surveys are conducted at a flying height of 16,600 feet above ground level, giving an image scale of one inch to one mile. At this scale, the radiometers view a 100 foot swath along the centre of each flight path, and this view is occulted for brief periods during film exposures. The idea of an in camera radiometer was originally put forward by Mr Jonathan Cocks of DSIR Crop Research Division, Lincoln.

Each radiometer output is digitised and multiplexed on to a small cassette tape recorder. The data can then be input directly to our computer, or demultiplexed and visually displayed on an analog chart recorder. The digital cassette tape system was developed by the thick film section of P.E.L. Electronics Division.

Figure 3 shows an aircraft color composite of part of the Darfield, Canterbury, test site taken on 14 November 1975. The output from radiometer channels one and four are shown in Figure 4, for a vertical track passing through the image center.

Aircraft coverage of the Darfield test site is scheduled at 2 - 3 monthly intervals, weather permitting, and so far two surveys have coincided with a successful satellite overpass to within 30 minutes. These occurred on August 2nd and on October 31st 1975. Figures 5 and 6 are a comparison of an August 2nd enlarged Landsat II composite of the test site with an aircraft composite obtained at the same time.

The object of regular coverage is to build up a "library" of seasonal imagery to determine the best periods in which accurate target classification can be made. These surveys have now been made since April 1975.

Our early photography was processed to a "gamma" of one, but for agricultural and forest targets the dynamic range of densities was insufficient to give an adequate range of color in the composite. The aircraft scenes shown in this report are processed to a gamma of two.

Some misregistration is apparent in the aircraft imagery. This is due to variations in focal length in the un-matched 80 mm planar lenses presently in use. Shortly it is hoped to order a matched set of 100 mm planar lenses to overcome this problem.

2.3 Ground Truth

Seven farmers in the Darfield area are enthusiastically co-operating with the Remote Sensing Section. At the time of each survey one of our staff visits each farmer and prepares a ground truth map of the farm, showing crop type, condition and previous treatment. Color composites of the previous survey are then given to the farmer, who is able to assist in visual interpretation.

The aircraft survey now includes a low-level run at 1000 feet over a line of paddocks, with a series of test panels of known reflectance set in the center of the run. The analysis of high and low level data will assist in estimating atmospheric attenuation and scattering.

During each underflight, measurements of solar (collimated) and global irradiance are made for each of the four MSS bands.

Details of the technique used are given in the next section. Other parameters, such as soil moisture, can only be inferred at the present time, for instance from the farmer's daily rainfall measurements.

2.4 Atmospheric Measurements

It is reasonable to assume that atmospheric attenuation will vary on a day-to-day basis, and throughout the year, even for cloud-free days. Moreover, target irradiance is affected by the presence of clouds even at considerable distance from the sun.

For meaningful comparison of time-separated imagery, it may be necessary to convert apparent target spectral radiance at the sensor into spectral reflectance. We therefore have a program to measure global irradiance and atmospheric extinction coefficients at fairly regular intervals, in each of the MSS spectral bands. Eventually it should be possible to predict the likely long and short term variations in these parameters.

Global irradiance is measured with a Gamma ERTS radiometer, using the irradiance attachment. A collimating tube is fitted to the same instrument to measure collimated solar irradiance. In principle the extinction coefficient γ can then be calculated for solar zenith angles of less than 75° by the expression:

$$\gamma = \cos \Omega \log_e \left\{ \frac{I_o}{I} \right\} \qquad .... \; 2.4.1$$

where Ω = solar zenith angle

I_o = spectral irradiance at top of atmosphere

I = measured spectral irradiance at target.

Direct evaluation of this expression requires that I_o is known within the bandwidth of the measuring instrument, and that the instrument is accurately calibrated in absolute terms.

We prefer to use an alternative technique in which collimated measurements are made with a sun tracking sensor over a period of some hours centered on solar noon.

On a clear day with consistent conditions, solar irradiance is largely a function of atmospheric path length, and is therefore

related to zenith angle. The time varying data (I) is fitted to the expression 2.4.2, using an iterative least squares fit program.

$$I = I_o \exp(-\gamma/\cos\Omega) \qquad \ldots.\ 2.4.2$$

The advantage of this procedure is that γ is determined only by the shape of the curve, and not by absolute values of either I or I_o. A typical result for Wellington is shown in Figure 7.

From the tabulated spectrally dependent values of I_o, (Thekaekara et al. 1972), it is possible to use this program to derive an absolute calibration coefficient for the instrument, provided that the spectral response of the instrument is known. The calibrated instrument can then be used to make meaningful single measurements of γ. This method of determining γ is similar to that used by Shaw et al. (1973).

It is intended to compile a "library" of this data for future use in image analysis.

2.5 Radiometry and Spectral Reflectance

The spectral response of a sensor is largely determined by the spectral characteristics of the filter and detector. For the relatively wide MSS bandpasses, the spectral transmission of practical filters tends to vary considerably, even between batches of the same design.

The differences between sensors with nominally the same MSS band responses can prevent meaningful comparison of spectral signatures derived from these sensors. That is, the product of target spectral radiance with each instrument response will produce results which can only be related if the target and instrument responses are all known.

With the aid of the P.E.L. Photometry Section, we have measured the filter characteristics and total spectral responses of all our radiometric instruments. The tabulated data is filed in the computer and can be combined with any tabulated target or source function to predict the instrument output for any given situation. Absolute calibrations are also conducted in the Photometry Section

using NPL standard sources.

A grating spectrometer suitable for field use is available to the Remote Sensing Section, and suitable input/output optics are being designed and made by the P.E.L. Optics Section. The plan is to use this instrument to obtain continuous spectra of targets as a function of time of year and for different environmental conditions. This data will be necessary to determine probabilities of achieving target separation, and optimum filter bands for specific problems.

2.6 Progress in Processing Computer Compatible Tapes

Since late 1975, effort has been directed towards the processing of NASA produced computer compatible tapes (CCT's). Our ultimate interest is in the quantitative data anlysis of Landsat and aircraft imagery, which is best performed using this type of data product.

We have at our disposal two in-house computers, an HP 2100 and a Varian 620 F, and a terminal to an IBM 370/168 that serves Government departments in the Wellington area.

The approach we have adopted has been largely determined by the number of data elements contained within each Landsat scene and the available peripheral equipment.

Our overall plan is first to decode the EROS CCT of 800 bpi or 1600 bpi on the IBM 370, then perform the striping removal and sensor calibration adjustments and later execute any cartographic corrections. The data for a reduced area of interest is then written on to 800 bpi 9-track tape for treatment in the in-house computers. These IBM programs are being developed in PL/1 for greatest data handling flexibility and machine independence. At this time (March 1976) the tapes can be completely decoded, reformatted and selected areas are being written on to disc storage before transferral to magnetic tape.

The reformatted tapes are then used by a library of image processing and interpretative programs in the HP 2100.

At present our computer analysis is restricted to a 128 x 128 pixel image which includes our test area near Darfield (43.5°S, 172.2°E). We think it is best to do a detailed study of this area before attempting to analyse larger regions.

A package of basic programs for use in the HP 2100 has been completed. These perform such tasks as reading a specified band of a selected region of a scene and enhancing it by removing line errors and performing histogram equalisation. Scaling and band ratioing is also possible.

We have as yet no output device suitable for producing a whole Landsat image in pictorial form, but have developed programs for printing a 128 x 128 pixel image on an electrostatic line-printer, via the Varian 620 F. We plan to use the lineprinter outputs to obtain photographic negatives suitable for color compositing, as an interim step before considering the purchase of a drum write facility.

We are currently developing programs for unsupervised cluster analysis, which will be evaluated with test area data. It is hoped that the programs will be fast enough to permit the eventual analysis of large portions of Landsat images using the existing computer facilities, but anticipating the availability of a photo-write machine, on which land-use maps and thematic maps can be produced directly.

2.7 Collaboration with CSIRO, Australia

Since its beginning, the Remote Sensing Section, has established a working relationship with the remote sensing group at the Minerals Research Laboratories, Sydney, headed by Dr M.J. Duggin. We are now actively collaborating in the fields of radiometry, instrument calibration, atmospheric measurements and CCT processing.

One of us (PJE) spent three weeks of November 1975 making irradiance and ground radiance measurements with the Australian field team at Menindee near Broken Hill, and at Wagga Wagga, N.S.W.

One of the Australian group (Robert Cook) has just concluded a visit to PEL in which the spectral responses and absolute calibration of the Australian equipment has been measured and compared to the PEL instruments. The standard sources used by both Laboratories have also been intercalibrated.

The results of this work should appear in the next quarterly report and as a joint publication later in 1976.

2.8 Data Storage, Retrieval and Dissemination

Within a day of their receipt at P.E.L., the photographic data products are assembled together with a copy of the P.E.L. file sheet and the standing orders are despatched to the Co-investigators.

Within this section a complete set of 70 mm negative and positive products, and 9 x 9 inch positive transparencies are kept for the production of color composites and our interpretative work. This is the "ready use" set. If the total number of data products permits, an "archival" set is also created and kept. At this stage no CCT's have been received under the Landsat II investigation programme.

A "browse file" of 8" x 10" prints of each band is in the process of being established. Prints in the browse file are allocated according to the geographic area covered.

Data from the master file sheet is entered into the HP 2100 computer operating in the time-shared basic mode. The accessing programmes have been written so that an enquirer with a terminal simply runs the program and answers a series of questions, e.g. date period of data coverage desired, geographical co-ordinates, sensor type etc. The relevant scenes are then listed with descriptive information. The same output can be sent direct to a telephone enquirer.

3. ACCOMPLISHMENTS AND IMMEDIATE OBJECTIVES

The program so far has consisted of building up the capability to process Landsat imagery, and to acquire essential backup data in

the form of aircraft and ground truth coverage of selected test sites.

A considerable quantity of satellite imagery, co-incident aircraft imagery, radiometric, atmospheric and ground truth data has been acquired. The next phase of the investigation is to analyse this in detail. The following topics are part of our immediate investigation program.

3.1 Correlation of Radiance/Photographic Density Results

Simultaneous aircraft and satellite coverage of the test site has resulted in three sets of related data:

(a) Image density obtained from MSS band negatives using a Gamma microdensitometer.

(b) Target radiances of the same images from the camera radiometers.

(c) Landsat MSS target radiances obtained from CCT's of the same area.

Our preliminary attempts to correlate (a) and (b) have only been partially successful, because of the large number of variables involved. It is hoped that future analyses will greatly increase our understanding of these processes.

3.2 Analysis of Imagery

Comparison of the Landsat II composite in Figure 6 with the simultaneous aircraft composite in Figure 5 shows that individual paddocks of five hectares or greater can be identified on the satellite photographic product. At the winter period when these were taken, the range of spectral signatures is not great, and it is difficult to make meaningful comparison with the same scene taken at other times of the year, such as the scene of Figure 8.

Figure 8 was composited from monochrome transparencies generated on a photowrite machine at the remote sensing section, CSIRO, Australia, from our original Landsat I CCT. Preprocessing of the image included scaling the dynamic range of each band to fill the available range of film densities, and the transparencies were produced to a pixel size of 0.1 mm square which ensures that resolution is not degraded by grain.

The apparent improvement in spatial resolution, compared to the scene in Figure 6, could be partly due to the difference in time of year. We are hoping to receive a Landsat II CCT of this scene shortly, from which a similar photowrite product will be made.

From the aircraft and satellite imagery already obtained, we now hope to determine:

(a) the optimum time of year for the classification of specific targets, and

(b) the coefficient of variation of target radiance in each band.

Much remains to be done to relate ground truth results to the imagery. It is already evident that parameters such as soil moisture, previous treatment and grazing can greatly affect the spectral signature. In one of our aircraft images, two out of a group of five pastures had been sprayed with 2-4-d a few days prior to our coverage. On the ground, five pastures were indistinguishable to the eye, but the sprayed pastures were clearly seen on the color composite. The difference between cow-grazed and sheep-grazed pasture can be easily seen in Figure 5.

3.3 Atmospheric Effects

Our atmospheric extinction measurements have been described in section 2.4, with some typical values in Figure 7. Now we wish to correlate extinction with the observed differences between target radiances measured during high and low level aircraft runs, and from Landsat II.

Differences exist between extinction coefficients measured by our methods, and those described by Duggin et al. (1974). One of the purposes of our collaborative work in this area is to find the cause of these differences.

4. SIGNIFICANT RESULTS

At this early stage of our program, we have no results other than those detailed in previous sections.

5. PUBLICATIONS

None released during reporting period.

6. PROBLEMS

At present, most of our problems appear to be logistic in nature. Our dialogue with the Co-investigators indicates that in some cases they may require data products in different form to the color composites presently produced in our section. The development of our service facilities, for both a variety of data products and for the provision of interpretative equipment, is an area which will require further effort.

7. DATA QUALITY AND DELIVERY

7.1 Accession Reports

These are of great value particularly in the listing of data quality, missing bands etc., and the geographic co-ordinates furnish the data base for our computerised geographic search routines. Their timing, some 3 - 4 weeks before data product receipt, is quite satisfactory for user forward planning.

7.2 Non-U.S. Standard Catalogs

These are appreciated as they provide overall coverage details that can complement New Zealand based studies. They are mainly used as reference material for user enquiries.

7.3 Data Users Handbook

To date we have not received a copy for Landsat II. This will be a disadvantage when planning complementary ground experiments such as the siting and alignment of cartographic reflectors, and when comparing aircraft and satellite radiance results.

7.4 EROS Photographic Data Products

The N.Z. data products are forwarded from EROS to the N.Z. Embassy in Washington from whence they are generally sent to us via the diplomatic bag and DSIR Head Office in Wellington.

All scenes for which we have received notification have eventually arrived. However, the overall delay between satellite acquisition and delivery to P.E.L. has been rather long at times. For instance, the first Landsat II scene of N.Z. was taken on August 3 1975, despatched from EROS on October 1, and received by us at the end of October. No damage due to transit has been experienced. At times the standing order products for a single scene have arrived intermittently over a period of 3 - 4 weeks.

Density measurements made of the 70 mm negative grey scales show quite large differences between scenes. The differences are consistently apparent in our color composites. We intend to make diffuse density measurements of each scale and list the results at the end of the next reporting period.

7.5 Computer Compatible Tapes

All our work with CCT's so far has been carried out with an ERTS-1 scene, purchased before the beginning of this investigation. We have two current requests for Landsat II scenes, no 2192-21265 requested on 19 November 1975, and no. 2282-21254, requested on 15 January 1976. We assume that these tapes remain the property of NASA, and will be made available to us for the duration of the investigation.

8 & 9 RECOMMENDATIONS AND CONCLUSIONS

Our experience so far has shown that Landsat II imagery can provide meaningful information for a variety of users in this country. The examples given in this report show that the photographic products can be used for classification of targets into the major categories, and for synoptic studies of whole regions. However, many targets, such as agricultural paddocks tend to be small, of the order of five hectares or less, and comparison with the aircraft imagery of the same scene shows that

subtle distinctions in spectral signature can be lost.

The preprocessed imagery in Figure 8, produced directly from computer compatible tape, seems to give an improvement in spatial resolution, and more particularly enables the user to scale the dynamic range to suit the range of targets under examination.

We are concerned that prospective users may not realise the full potential of Landsat imagery by a first examination of the standard photographic product, particularly at a small scale. We feel that the nature of some of our targets is such that their classification would require the use of CCT's and possibly the use of an output device such as the photowrite. For instance, differences in low reflectance subjects such as forest blocks, can be much more easily distinguished in the preprocessed imagery.

The problems of interpreting aircraft imagery, particularly of extrapolating from one frame into another, have convinced us of the value of the synoptic view from a satellite. If future Earth Resource satellites have an improved linear resolution of even a factor of two, this could have a profound effect on the operational uses in this country.

An operational system would almost certainly require the timely reception of CCT products. Perhaps it is not too early to consider how an operational system could be implemented in the future, either from an Australasian tracking station or by some method of rapid data transfer from the U.S.A.

We would like to conclude by expressing our appreciation for the help given by the staff at Goddard, and particularly to Dr Robert Price and others who meet with us via the "peacesat" communciation satellite. These question and answer sessions are a great help to us, and encourage a growing interest in satellite remote sensing in this country.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the considerable help given by the New Zealand Aerial Mapping Co. Ltd, and by the Optics, Electronics, Instrument Development and Photometry Sections of P.E.L.

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Shaw et al. (1973) - Investigations of atmospheric extinction using direct solar radiation measurements made with a multiple wavelength radiometer. J. App. Meteorology, 12, March 1973, 374-380.

Thekaekara et al. (1972) - Proposed specification for the solar and air mass zero solar spectral irradiance. NASA SP-298 Space simulation 1972 Paper No. 82 955-968.

15a

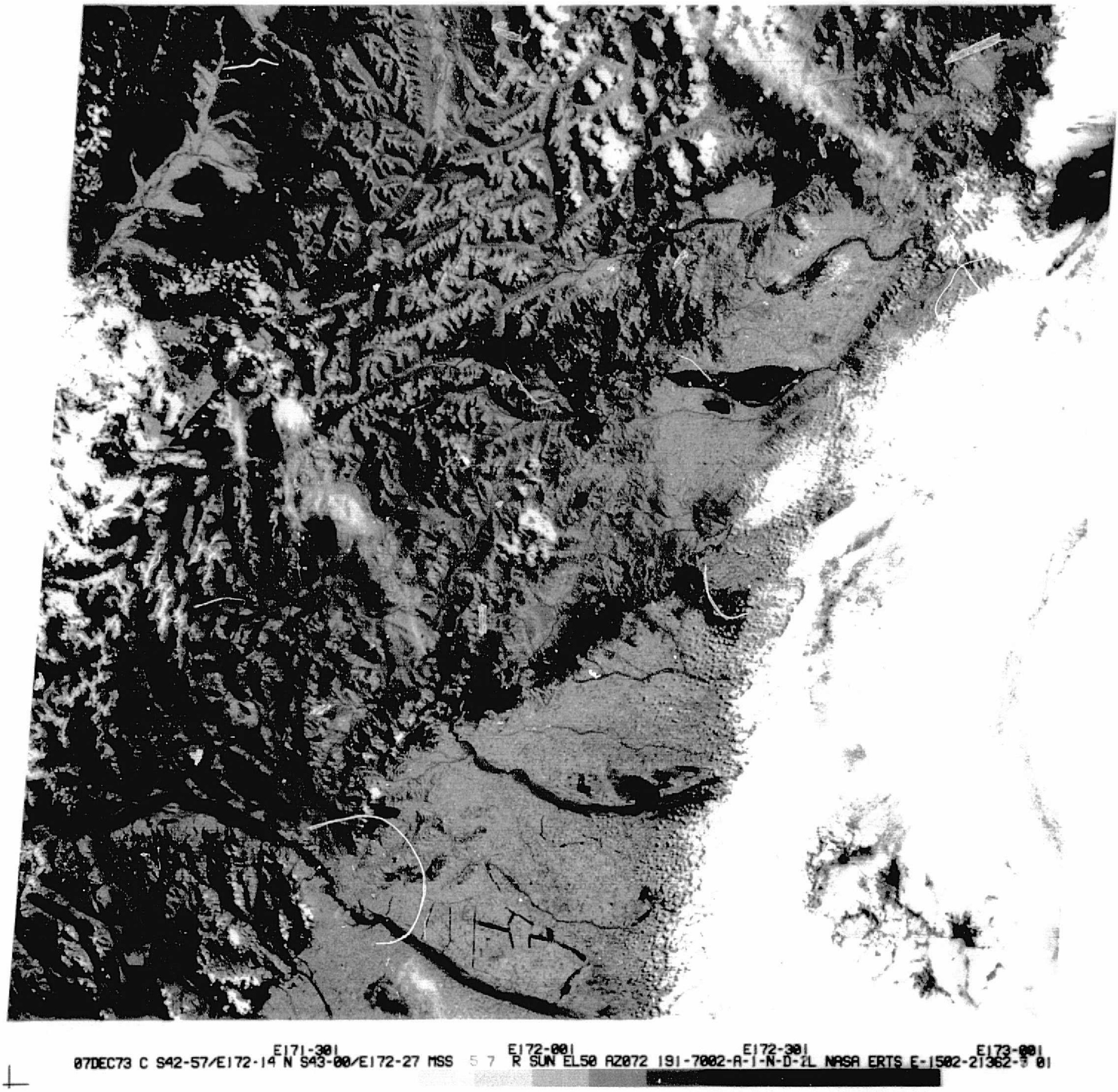

Figure 1 - Full-scene color composite of Canterbury, produced by sequential exposure - Landsat I 1973

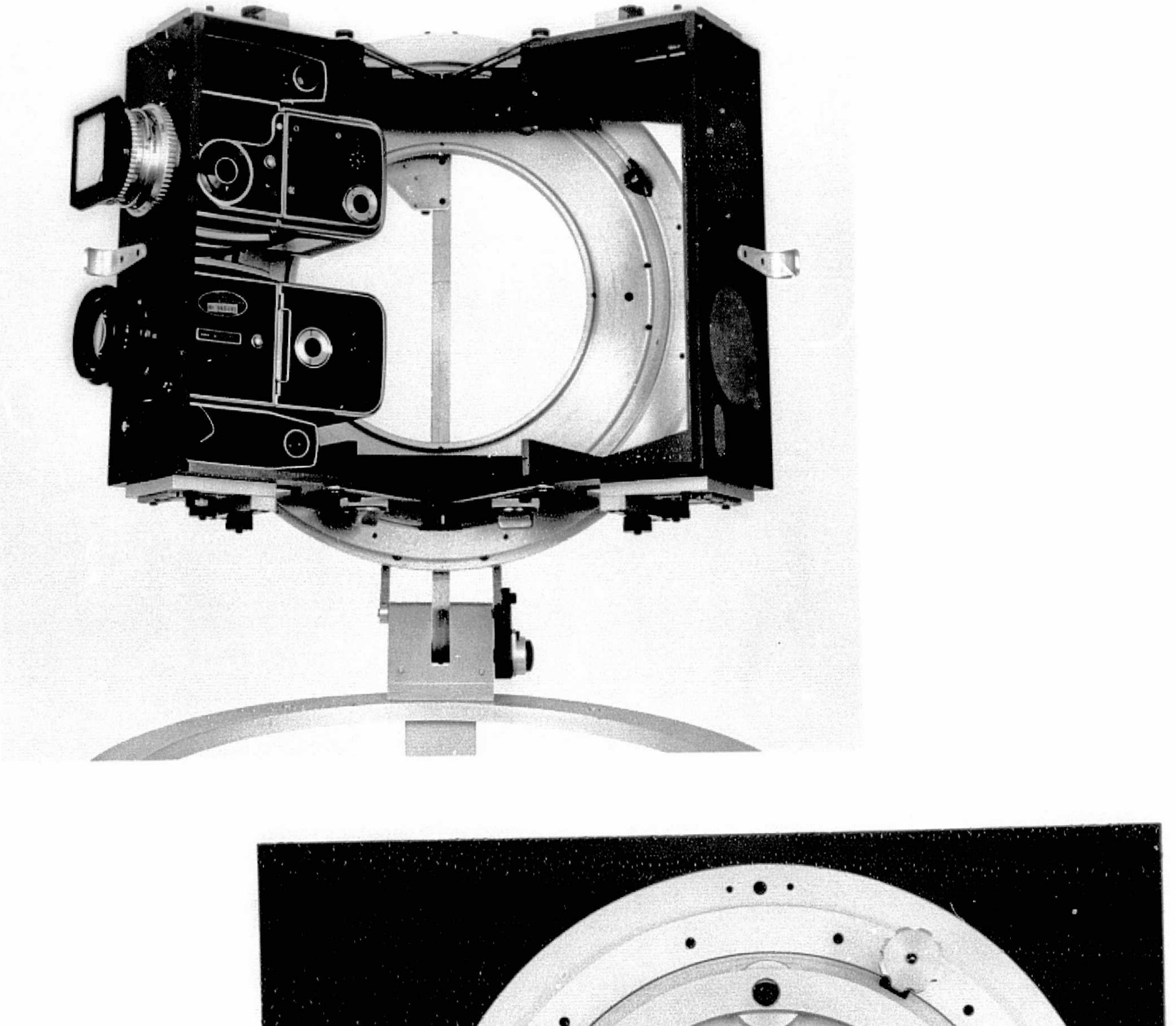

Figure 2(a) - Aircraft multispectral camera system.

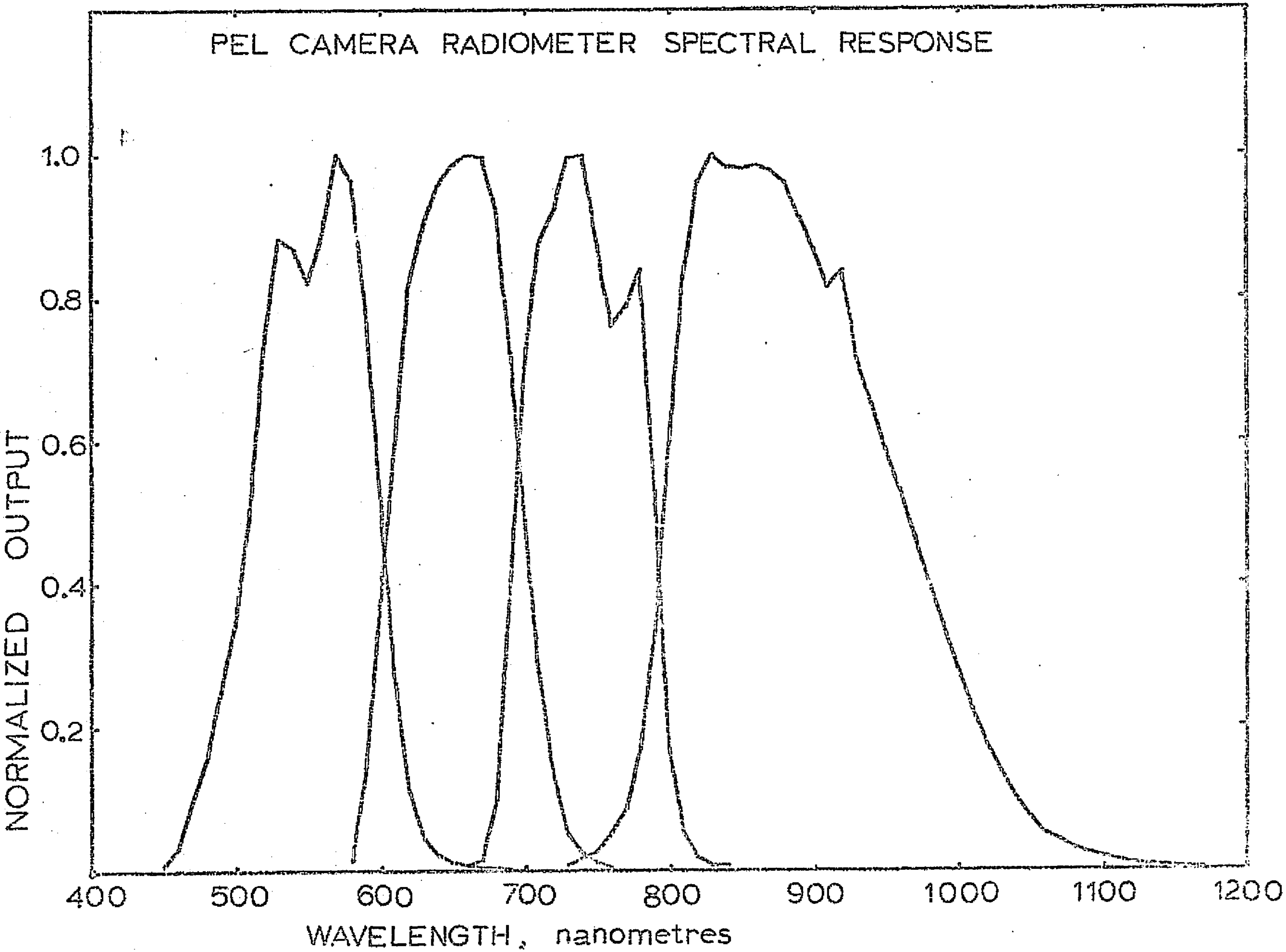

FIG 2b SPECTRAL RESPONSES OF CAMERA SYSTEM

Figure 3 - Part of the Darfield test site - Aircraft color composite - MSS bands 4, 5 and 7 - 14 November 1975

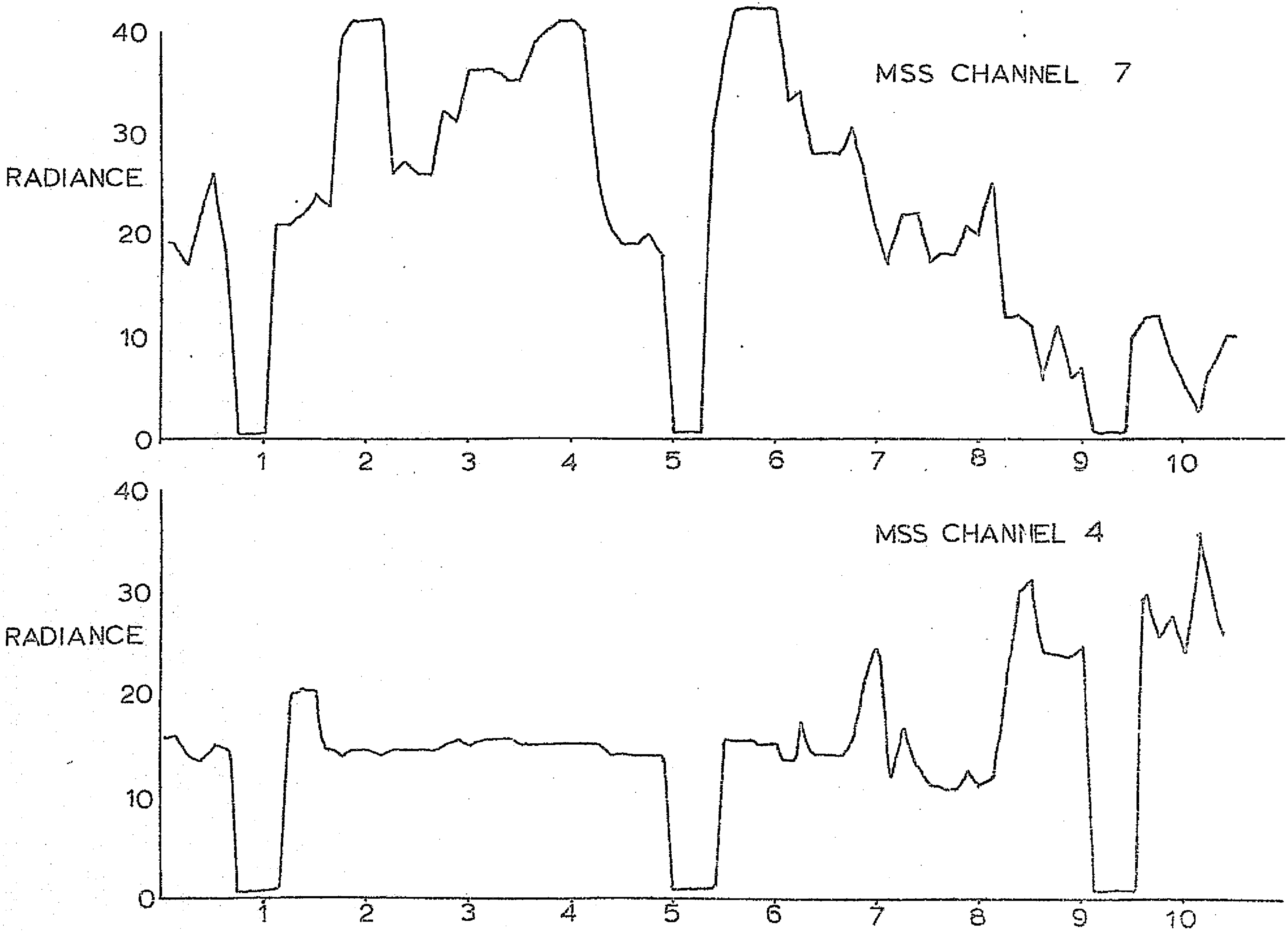

FIG 4 CAMERA RADIOMETER OUTPUT

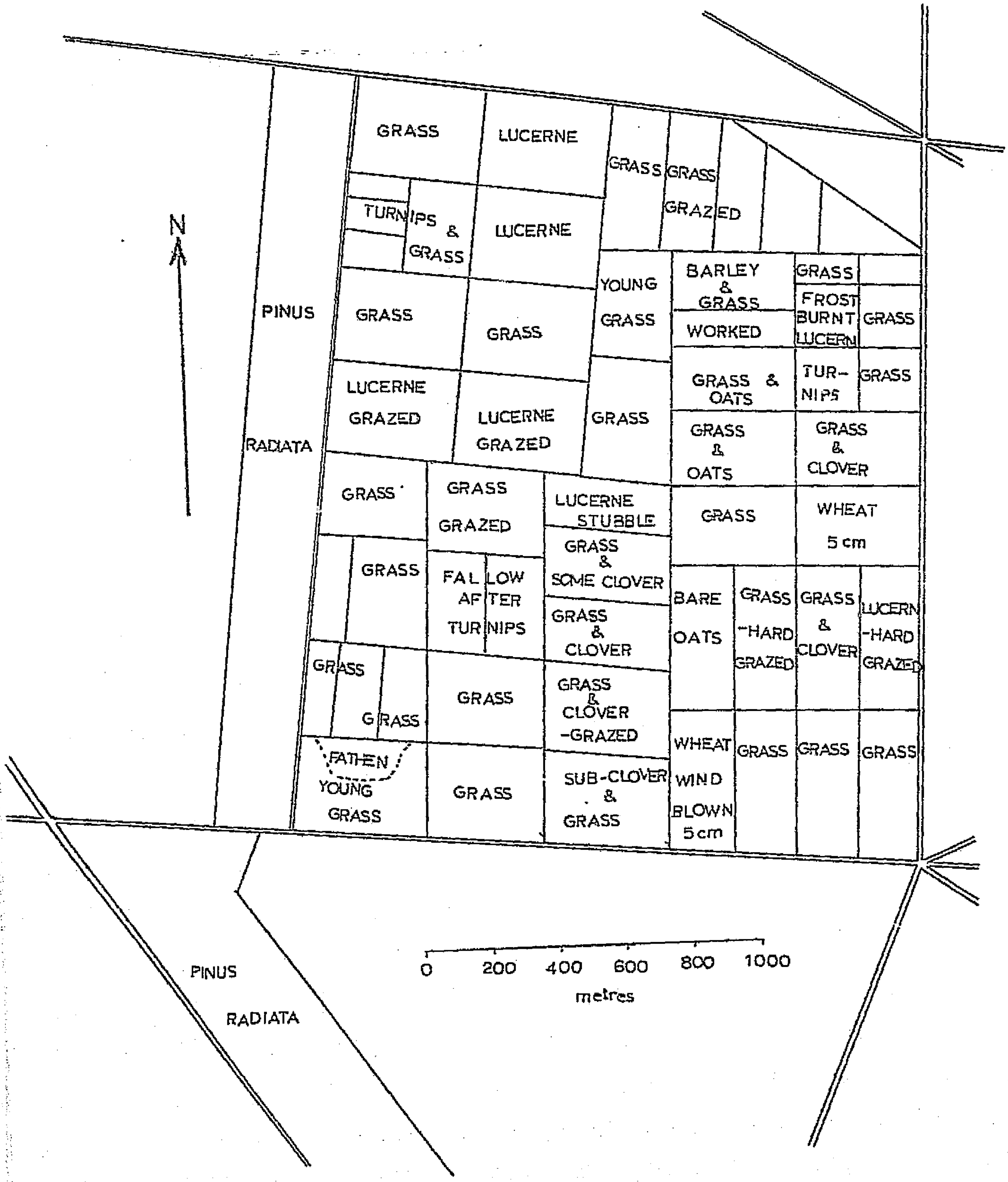

FIGURE 5(a)

GROUND TRUTH MAP
2nd AUGUST 1975

15G

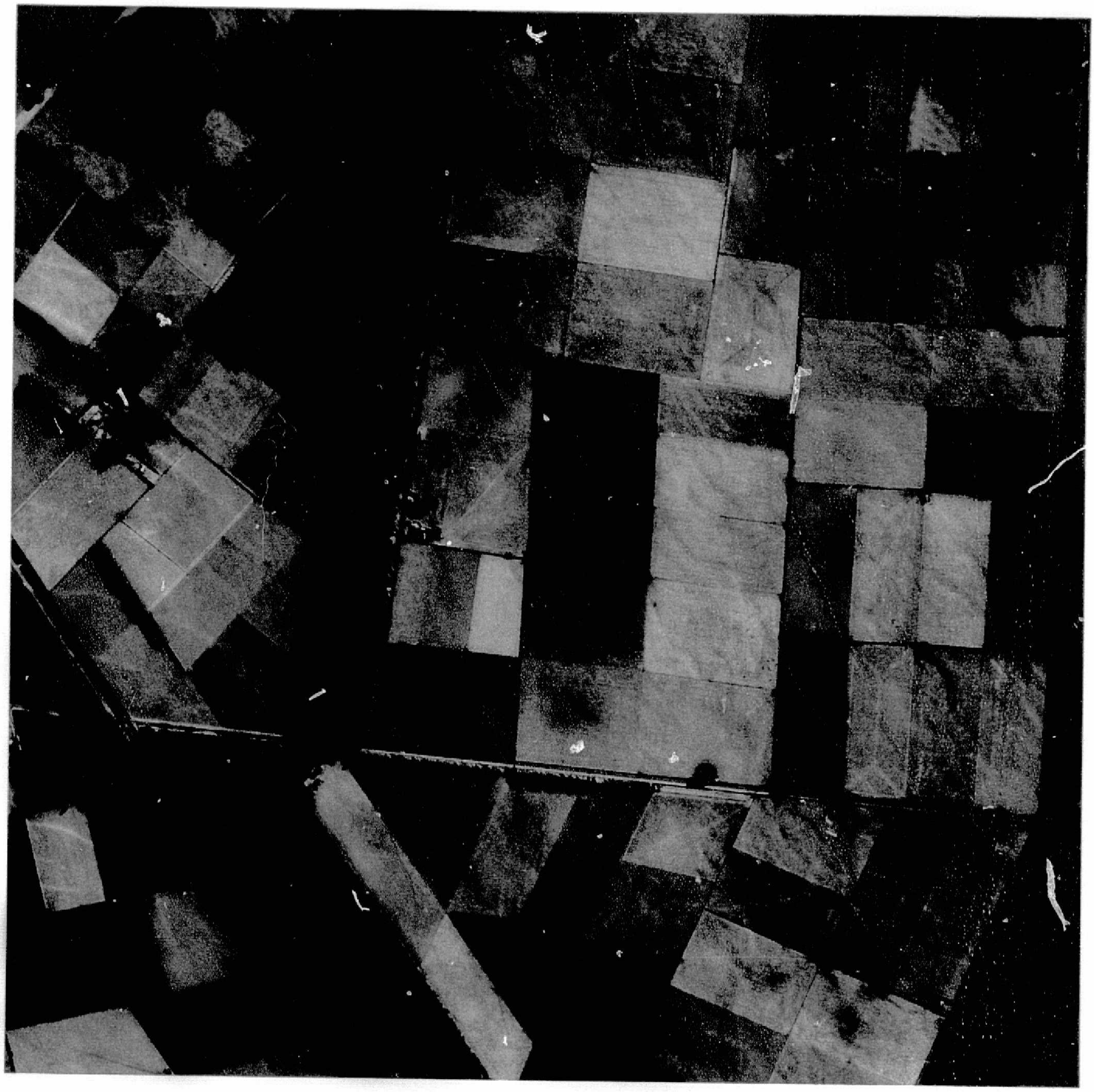

Figure 5 - Aircraft test site composite and ground truth map 2 August 1975 survey.

15h

Figure 6 - Landsat II test site composite (enlarged)
2 August 1975 survey.

IRRADIANCE MEASUREMENTS

WELLINGTON, N.Z.

24th JULY, 1975.

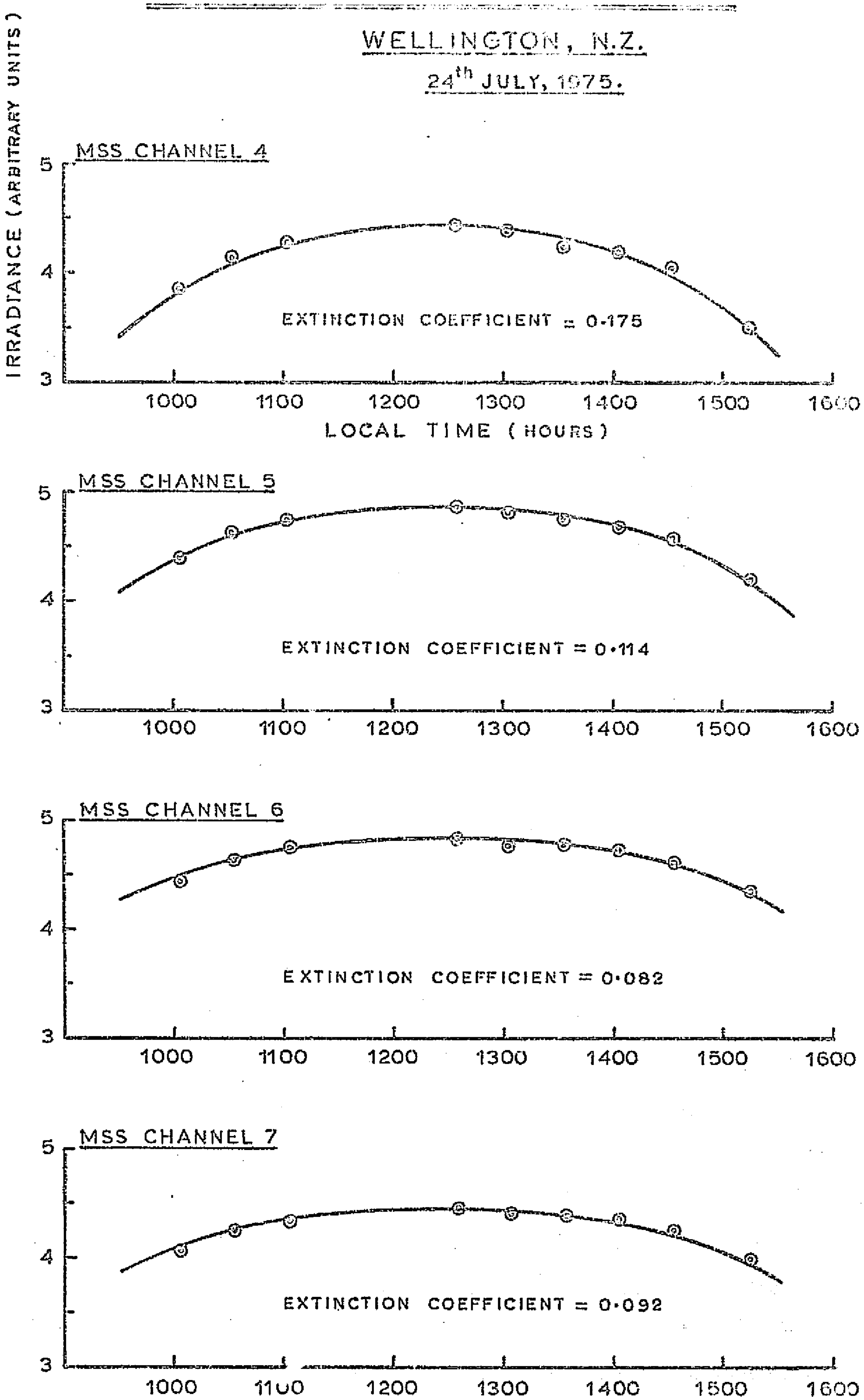

FIG. No 7

Figure 8 - Composite of test site - Landsat I 1973 - Monochrome transparencies produced on CSIRO photowrite machine.

15 K

APPENDIX

Physics and Engineering Laboratory personnel involved in the Landsat II Investigation Program.

M.C. Probine - Director, Physics and Engineering Laboratory, Department of Scientific & Industrial Research.

B.Sc., M.Sc., Ph.D.(Leeds), F.Inst.P., F.R.S.N.Z. Dominion Physical Laboratory 1947-62; Physics and Engineering Laboratory 1962-Present (appointed Director in 1967). Member of Executive - N.Z. Industrial Design Council, Wool Research Organisation, Logging Industry Research Association, Manufacturing and Processing Committee of National Research Advisory Council, Consumer Council, Ross Dependency Research Committee. Interests: Biophysics, Science Administration, Industrial Development.

M.A. Collins - Head, Physics Division.

M.Sc(Hons), F. Inst. P., M.I.E.E., C. Eng. Dominion Physical Laboratory (N.Z.) 1958-62, National Physical Laboratory (U.K.) 1963-65, Physics and Engineering Laboratory (N.Z.) 1966-Present. Developed cosmic ray neutron monitor, member of magnetic resonance team which designed maser preamplified ESR; member of P.E.L. team developing UMER techniques. Interests: magnetic resonance, scientific computing, science administration.

P.J. Ellis - Section Head, Remote Sensing.

C.Eng., M.I.E.R.E., Ph.D (Reading U.K. 1971) Lecturer in Electronics, Heriot-Watt University, Edinburgh, Scotland 1971-73. Member of U.K. design team responsible for the Selective Chopper Radiometer (SCR) on the Nimbus IV and Nimbus V satellites. Interests: electronics, energy conversion, radiometry, electro-mechanical instrument design.

I.L. Thomas - Scientist, Remote Sensing.

B.Sc. (Melbourne 1966), Ph.D (Melbourne 1972) in Auroral Physics. M. Inst. P. Tutor and research associate University of Calgary, Canada 1971-73 in low light level auroral morphology. P.E.L. Auroral Station N.Z. 1973-75 - auroral studies in N.Z. and Antarctica. Joined P.E.L. Remote Sensing Section in June 1975. Working in areas of IBM 370 CCT decoding and rectification, data cataloging and dissemination, ground aspects of flying programme. Interests: general data processing, water resource, photogrammetric, atmospheric, auroral and Antarctic research.

M.J. McDonnell - Scientist, Remote Sensing.

B.Sc. (Hons) in Physics (Canterbury 1973), Completing Ph.D in digital image restoration (Canterbury, thesis submitted - December 1975). Joined P.E.L. Remote Sensing January 1976. Currently working in the areas of digital image enhancement and cluster analysis. Interested generally in signal processing techniques.

APPENDIX (Cntd)

A.D. Fowler, Technical Officer, Remote Sensing.

1966-67 Toronto, Canada - Courses in photography London University Ontario and Winona Indiana. 1969-74 Photographer at Chemistry Division, D.S.I.R. 1974 Remote Sensing Section, P.E.L. - development of color processing laboratory, multispectral color compositing techniques, instrument calibration including spectral response measurements.

R.S. Mason, Technician, Remote Sensing, N.Z.C.S. - Applied Physics.

Technical training P.E.L. 1972-74. Joined Remote Sensing Section 1974. Assigned to aerial multispectral survey preparation, construction of electronic equipment and instrument evaluation. Awarded Commonwealth Education Scheme Travel Award in 1975, which will consist of 12 months at the Canada Centre for Remote Sensing, Ottawa, Canada, beginning April 1976.

PART II

MAPPING LAND USE AND ENVIRONMENTAL STUDIES IN NEW ZEALAND

Investigation No.: 2823C

Co-Investigator: Mr Ian F. Stirling

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Wellington, New Zealand

Telephone No.: Wellington 735-022, ext. 286

Author: Mr Douglas McK. Scott.

CONTENTS

INTRODUCTION

Although it is freely admitted by all concerned that Landsat was neither intended nor designed to suit cartographic requirements, one of the main aims of this investigation is to establish to what extent the data contained on the imagery might be applied to the cartographic needs of the Department of Lands & Survey.

It is this aspect of our initial Proposal that has to date received the bulk of our research attention.

Our investigation began at the beginning of December 1975 when the arrival of the first Landsat II imagery at the Department coincided with the appointment of this report author to organise and co-ordinate tests and investigations by the various units within the Department that would benefit most from the use of Landsat imagery.

The units involved are Cartographic draughting, Aeronautical Mapping, Land Evaluation and Planning, Photogrammetry and Remote Sensing Interpretation.

Since this is our first report, compiled after a very short duration of investigation, it will take the form of relating our intentions within these units rather than try to give scientific analyses and technical breakdowns with resultant conclusions.

Breakdowns and conclusions will come in later reports.

1.0 The Cartographic Draughting Branch has as one of its most important functions, the responsibility of pulling together the information received from the other branches of the Department. It must then compile and design the finished map to represent all the contained data in a legible and easily understood manner. One of the techniques extensively used in this is hill shading. This is done by one of two methods; first, interpretation of contours; and second, by interpretation of aerial photographs.

When hill shading maps at a scale of 1:250,000 or smaller the scale of photography is not always conducive to rapid interpretation, and it is this fact that makes Satellite Imagery an exciting prospect for hill shading purposes. Not only can it give information easily and quickly at the desired

scale, but it can also show up general geoform trends over much larger tracts of land in one shot, thereby aiding the cartographer in the design of his map.

Coupled with the above is the excellent apparent facility to up-date and revise existing, possibly long-established, small scale maps, checking on, in particular, coastline invagination generalisations that might have occurred at the time of original survey. The same applies to inland water-courses, i.e. rivers and streams, where change can occur almost overnight due to flash floods, changes over a longer term for hydro-electric power supply purposes. On the face of it the potential benefits are many in this section.

<u>2.0</u> The Aeronautical Mapping Branch has been using the imagery as an interpretation tool for relief shading and land-form recognition purposes aiming to improve the information content of the Aeronautical Charts they produce. Theirs is a very limited investigation and thus far are fairly satisfied as to their requirements from the imagery.

<u>3.0</u> One of the more important investigations with Landsat imagery centres around our Evaluation and Planning Branch. In pursuit of this research we are, and, in the future will be even more so, involved with Dr Ellis's team at the Physics and Engineering Laboratory of the Department of Scientific & Industrial Research. Our function here is in the provision of Land Use Maps for evaluation and planning purposes.

<u>3.1</u> To date the information required has been acquired by conventional ground investigation methods. By use of Landsat Data and under-flying sorties using our own I^2S camera system, we aim to cut the leg work down to acceptable proportions.

<u>3.2</u> Dr Ellis has, as part of his equipment, a Hasselblad multi-camera system. When the two camera systems have been calibrated one to the other as far as is possible, then the interpretation of imagery can go ahead on a much greater scale.

<u>3.3</u> Unfortunately, land evaluations by means of remote sensing techniques is in its elemental stage as far as we are concerned, but we are learning fast and have high hopes for the future of this part of the investigation.

4.0 Photogrammetric Branch has several responsibilities within the Landsat Programme in New Zealand.

4.1 The first is in the dissemination of information to other government departments and to the general public. This is being done through our Photographic Library here in Wellington. To aid in this task we have produced two maps, one for Landsat 1 and another for Landsat 2, which supply all the information that we feel an inquirer might need to give an overall picture of Landsat coverage for New Zealand. See attachments 1 & 2.

4.2 The next stage is to provide information on the types of product available, e.g. 9 x 9 colour composites, 9 x 9 monochrome prints of individual bands. For this we will use a similar format to the attachments.

4.3 Users obviously want to know the area covered by any particular scene and to see for themselves the extent of, for example, cloud cover. To this end we designed a photographic product which displays all four bands on the one sheet providing in effect a "Quick Look" print. In fact these prints are now known as just that. See attachment 3.

4.4 As and when we receive 70mm negatives of a scene, our first task is to produce these prints for dissemination to interested agencies.

4.5 Photogrammetric Branch is further involved in the project by its investigation into methods of converting the information on the imagery into planimetric line representation. Our research to date centres around the establishment of the right type of image in the correct type of instrument.

4.6 Until recently colour composites made locally had proved troublesome because of colour registration difficulties. As well as making life difficult in interpretation of detail under magnification, operaters were afflicted with headaches and eyestrain. However, we were fortunate in having had the opportunity to use a colour composite produced by C.S.I.R.O. Australia.

4.7 This material was loaned to us by Ian Thomas of DSIR only recently and initial trials with the imagery show promise.

4.8 It came to us in colour composite form having been produced at a scale of 1:250,000 from monochrome transparencies constructed on CSIRO's (Australia) photowrite machine. The first colour composite model was apparently produced using monochrome negatives and this proved excellent to our needs at the time because we were attempting to separate woodlands, one type from the other, and the colour composites using negatives did this for us beautifully.

4.9 It is unfortunate that as yet we do not have photowrite facilities here in New Zealand, and it is to be hoped that consideration will be given very soon to amend this situation.

5.0 Our final project at present is the design, construction and testing of a reflector system for highlighting ground control points on the imagery. We are aware that similar experiments have been carried out elsewhere in the world but our purpose is to establish an efficient standard design and simple setting-up procedure. It is hoped to try our Mk.1 model during the April overpass.

5.1 Recently we have established with in Photogrammetric Branch a Remote Sensing Unit. The function of this unit will be to work closely with Dr Ellis and his team, and with the Land Evaluation Branch. Ultimately, it is intended to provide an inhouse consultancy service for Lands & Survey Department (and any other Government Department wishing information) on Remote Sensing Techniques and interpretation of imagery.

6.0 In conclusion two points must be made. First is that without the xpert help and service offered and freely given by the Scientists and Technicians at the Physics & Engineering Laboratory, DSIR, then much of what we have been able to do so far would not have been possible. The whole New Zealand Landsat Project is indeed fortunate in having such highly skilled and co-operative people devoted to the task.

6.1 Although this investigation is in its incipient stage, the future is easy to prognose; Remote Sensing Technology using both Satellite generated data and aircraft-borne camera systems will have an important part to play in the foreseeable future within the Department of Lands & Survey, New Zealand.

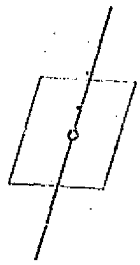
4a

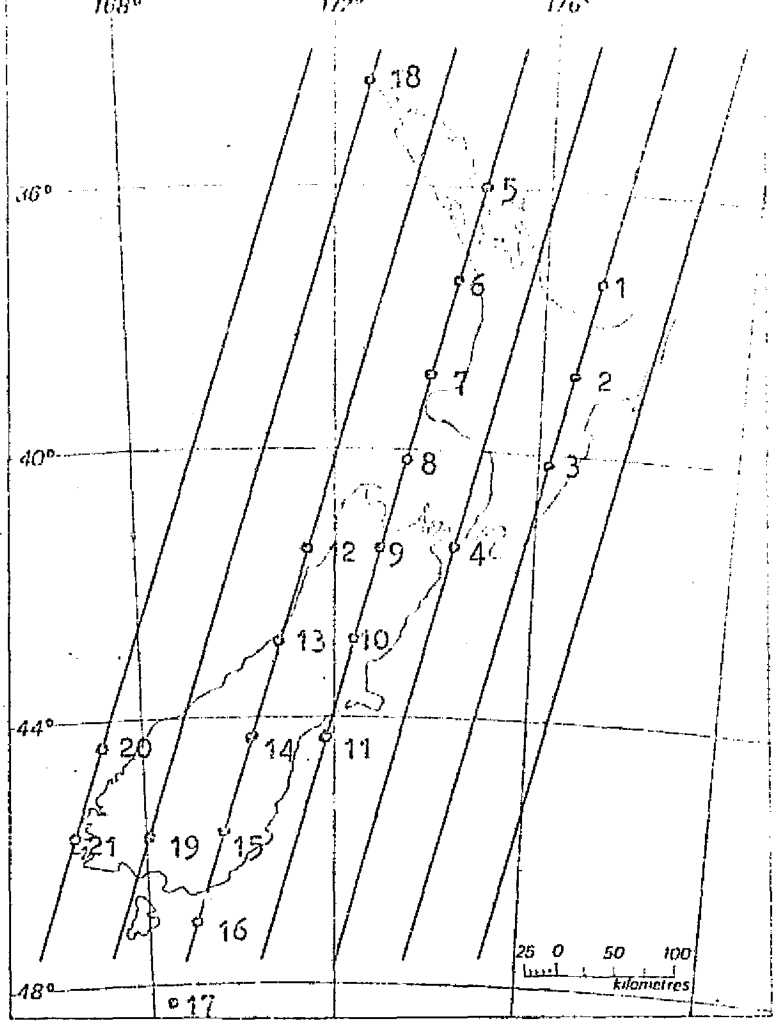
LANDSAT 1

Scenes received at Lands and Survey Dept. as at Feb. 27th 1976

Line represents Satellite track.

Area covered by one scene. Dot represents scene centre.





MAP INDEX Nº	I D Number		G.M.T. Date	SCENE CENTRE CO-ORDS S		E		LOCATION	COMMENTS
1	1482	21233	17.11.73	37	18	177	08	Bay of Plenty	
10	1502	21362						Christchurch	
11	1502	21365	7.12.73	44	21	171	41	Timaru	
13	1503	21421	8.12.73	42	58	170	49	West Coast	
14	1503	21423	8.12.73	44	22	170	17	Benmore	
15	1503	21430	8.12.73	45	47	169	43	Dunedin	
16	1503	21432	8.12.73	47	12	169	07	Invercargill	
17	1503	21435	8.12.73	48	36	168	30	S. of Invercargill	
20	1505	21540	10.12.73	44	28	167	35	N. Fiordland	
21	1505	21542	10.12.73	45	53	167	01	S. Fiordland	
1	1518	21230	23.12.73	37	20	177	05	Bay of Plenty	
2	1518	21232	23.12.73	38	46	176	36	Hawkes Bay	
3	1518	21235	23.12.73	40	13	176	06	Dannevirke	
4	1519	21300	23.12.73	41	37	174	11	Cook Strait	
5	1520	21340	25.12.73	35	56	174	11	Whangarei	
8	1520	21351	25.12.73	40	12	173	15	Farewell Spit	
9	1520	21354	25.12.73	41	38	172	44	Nelson	
1	1536	21223	10.1.74	37	25	177	09	Bay of Plenty	
6	1556	21331	30.1.74	37	22	174	22	Auckland	
7	1556	21334	30.1.74	38	48	173	55	Mt Egmont	
19	1558	21470	1.2.74	45	52	168	24	Southland	
12	1575	21395	1.2.74	41	36	171	26	Buller	
18	1648	21240	2.5.74	34	26	172	23	North Cape	

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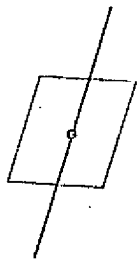
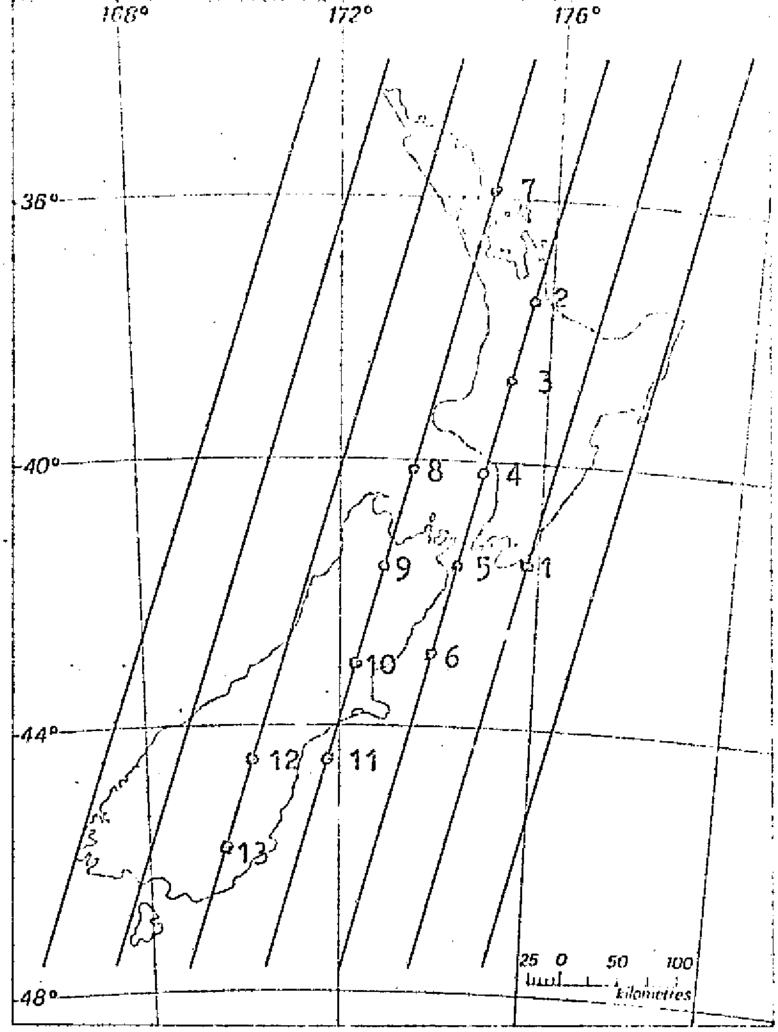
LANDSAT 2

Scenes received at Lands and Survey Dept. as at Feb. 27th 1976

Line represents Satellite track.

Area covered by one scene. Dot represents scene centre.





MAP INDEX Nº	I D Number		G.M.T. Date	SCENE CENTRE CO-ORDS S		E		LOCATION	COMMENTS
10	2192	21265	2.8.75	43	05	172	29	Christchurch	
11	2192	21272	2.8.75	44	30	171	57	Timaru	
7	2264	21235	13.10.75	35	53	174	55	Whangarei	
8	2264	21251	13.10.75	40	09	173	30	Farewell Spit	
12	2265	21321	14.10.75	44	26	170	30	Benmore	
13	2265	21323	14.10.75	45	50	169	57	Dunedin	
2	2281	21182	30.10.75	37	21	175	54	Tauranga	
3	2281	21185	30.10.75	38	46	175	25	Taupo	
5	2281	21194	30.10.75	41	38	174	24	Cook Strait	
9	2282	21252	31.10.75	41	36	172	58	Nelson	
10	2282	21254	31.10.75	43	02	172	27	Christchurch	
4	2299	21190	17.11.75	40	14	174	53	Wanganui	
5	2299	21192	17.11.75	41	39	174	23	Cook Strait	
1	2334	21132	22.12.75	41	33	175	46	Cape Palliser	
4	2335	21183	23.12.75	40	06	174	52	Wanganui	
5	2335	21190	23.12.75	41	31	174	21	Cook Strait	
6	2335	21192	23.12.75	42	56	173	50	Kaikoura	

4C

LANDSAT "QUICK—LOOK" PRINTS

Photo. credit: NASA, U.S.A.

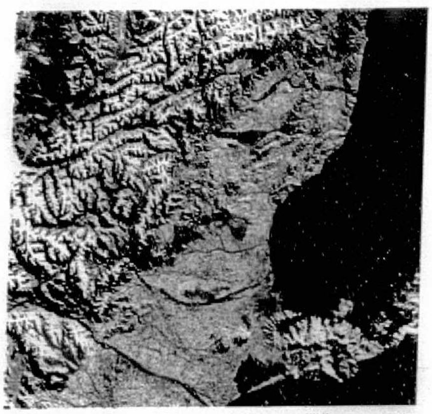
IDENTIFICATION NUMBERS

E— 2192—21265 —4 (BAND)
5 "
6 "
7 "

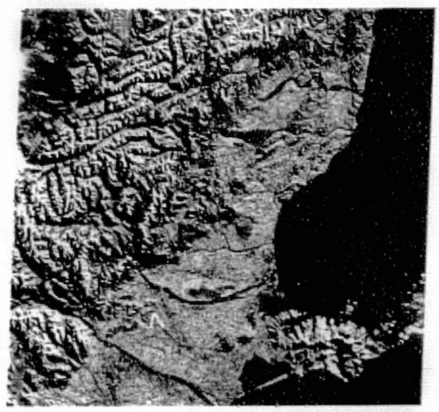
SCALE 1:3,369,000

BAND 4

BAND 5



BAND 6



BAND 7

Prints, or single enlargements of each band at 1:1,000,000, may be purchased from the Photo Library, Department of Lands and Survey, Private Bag, Wellington.

PART III

INDIGENOUS FOREST ASSESSMENT

Investigation No.: 2823B

<u>Co-Investigator:</u> Mr Michael G. McGreevy

<u>Agency:</u> Forest Research Institute

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<u>Telephone No.:</u> Rotorua 82179

<u>Author:</u> Michael G. McGreevy

LANDSAT PROGRESS REPORT

To date 14 images of New Zealand have been received. These contain only limited forested areas. Visual separation of forest and non-forest land has been successful on individual channels 4, 5, and 7. Difficulty has been encountered due to very steep topography in many forested areas. Also, areas classed as scrub and non-forest land on ecological survey maps has been difficult to distinguish from some forest land on individual bands. However, colour enhancements of channels 4, 6, and 7 have been successful in distinguishing areas classed as scrub forest in that area. Some non-forest land on survey maps actually contains juvenile forests.

Plot location and data for current indigenous assessment plots is being collected in anticipation of future images covering areas containing those plots. All available ecological survey maps have been obtained and the aerial photography from which they have been drawn has been made available to assist in explaining anomalies which appear in the comparison of these maps with Landsat imagery. Sufficient ground information exists to allow species type and volume information to be compared with Landsat images with minimal underflight requirements. Underflights of specific areas which include the west coast of the South Island, Mangakino, Urewera and Manaia will commence upon receipt of imagery of those areas.

Underflights of areas of central Kaingaroa State Forest for the purpose of quantifying disease levels (*Dothistroma pini* in *Pinus radiata*) on multi-spectral photography, thermal imagery, colour and colour infrared photography at scales ranging from 1:7000 to 1:23 000 have been conducted. Landsat imagery is also available over a portion of the area and it is hoped that compartment signatures of this imagery will be correlated with disease levels. Colour enhancements of these images have shown visual differences between areas of clear felling and between thinned and unthinned areas. No evaluation of disease level has yet been made.

We are currently engaged in developing a scanning microdensitometer which will aid in quantifying subtle differences in spectral signatures.

PART IV

SEISMOTECTONIC, STRUCTURAL, VOLCANOLOGIC AND GEOMORPHIC STUDY OF NEW ZEALAND.

Investigation No. 2823A

Co-Investigator: Dr Richard P. Suggate

Agency: N.Z. Geological Survey

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P.O. Box 30-386,
Lower Hutt, New Zealand

Telephone No.: Wellington 699-059

Authors: Dr R.P. Suggate
Mr Gerald G. Lensen

PRESENT PROGRAMME OF WORK

Images received are currently being assessed for suitability of the different bands in relation to morphologic variations. With the exception of some images Band 6 seems best suited as a single band, and combinations of bands are being investigated in relation to different rock types.

In order to make use of specialized local knowledge, copies of images are distributed to the appropriate district offices of the Geological Survey, where they are studied in relation to maps, field data and detailed geological knowledge, where available, of the area covered. Apparent new features are identified and those that are likely to yield the most promising results from ground investigation are being selected, according to the return likely to be gained from available financial and manpower resources.

RESULTS AT PRESENT

Many alignments so far recognized from images, for example in north-eastern South Island, confirm existing knowledge based on 1:250 000 mapping over the whole of New Zealand, 1:63 360 mapping over large areas, and many detailed published and unpublished accounts. In addition, some broad morphological differences, as in North Canterbury and Otago, previously only locally inferred appear to have regional significance. A preliminary study in the generation of stereopairs is under way. It is clear that some of the more attractive prospects for investigation are in rugged relatively inaccessible terrain; an additional problem is that of ground investigation in densely forested areas.

EXPECTED RESULTS

With complete coverage of New Zealand, particularly if it were available over the whole country in contrasting seasons, field investigations should substantiate, or perhaps disprove, the significance of features identified on images. Structural interpretation over regions of economic importance will be specially considered.

Although field work will in places be seasonal and slow, and future specific results are difficult to anticipate, we are confident that the high quality imagery will produce results not otherwise obtainable. Results need to be based on thorough field work, and are likely to be few in the short term.